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16OCT00 E574122-4 D00354
P01/7700 0.00-0025248.6

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1.	Your reference	MH/M088754PGB
2.	Patent application number *(The Patent Office will fill in this part)*	**0025248.6** 13 OCT 2000
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	HOLSET ENGINEERING CO. LIMITED ST ANDREW'S ROAD HUDDERSFIELD HD1 6RA
	Patents ADP number *(if you know it)*	6995583001
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM
4.	Title of the invention	A TURBINE
5.	Name of your agent *(if you have one)*	Marks & Clerk
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Sussex House 83-85 Mosley Street Manchester M2 3LG
	Patents ADP number *(if you know it)*	18004

6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day/month/year)*

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Continuation sheets of this form	-
Description	5
Claim*(s)*	1
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Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
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11. I/We request the grant of a patent on the basis of this application.

Signature.. Date 12 October 2000

MARKS & CLERK

12. Name and daytime telephone number of person to contact in the United Kingdom — MATTHEW HOLMES – 0161 233 5830

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DUPLICATE

A Turbine

The present invention relates to a turbine, and in particular to a power turbine of the type found in turbocompound engines.

A turbocharger comprises a drive shaft one end of which supports a turbine arranged to be driven by exhaust gases from an internal combustion engine. In automotive heavy duty diesel engines turbocharger shafts are supported in a housing usually by two separate floating bearings which are retained in position by circlips or some other conventional mechanical configuration. The turbocharger shaft is generally located axially by a separate bearing. In a turbocharger the end of the shaft remote from the turbine simply drives a compressor which is used to deliver air to the engine. In relatively small turbochargers for light duty engines it is conventional practice to support the turbocharger shaft in a one piece bearing which can either be fully floating or is pegged in position. This means that the shaft rotates within a one piece bearing which is a separate component from but does not rotate relative to, the surrounding housing.

In turbocompound engines, two turbines are provided in series, both driven by the exhaust gases of the engine. One of the turbines drives a compressor to deliver pressurised air to the engine and the other, a power turbine, is used to generate additional power which is transmitted via a mechanical connection. For example, in a power turbine a gear wheel may be fixed to the end of the shaft remote from the turbine and the gear wheel is used to transmit power into an appropriate coupling, for example a fluid coupling or other drive mechanism into the crankshaft of the engine. The power may however be transmitted by other means, for example hydraulically or electrically.

A turbocharger bearing system commonly comprises fully floating bearings. In a fully floating bearing, the shaft rotates relative to an inner bearing surface defined by a bearing body which also defines an outer bearing surface which itself rotates relative to a surrounding housing. In heavy duty turbochargers two separate floating bearings are provided, each retained in position by circlips or some combination of spacers and circlips. The turbocharger shaft is located axially by separate bearings. Load carrying oil films in fully floating bearings require relative rotation at both the

inner oil and outer bearing surfaces. In contrast, in a pegged bearing the outer oil surface of which does not rotate relative to the surrounding housing, only the inner film supports the rotating shaft, the outer film providing only vibration damping.

In a power turbine, in which additional power generated is fed back into the crankshaft of the engine via a gear wheel on the turbine shaft, different loadings are applied to the shaft bearing system as compared with loadings in a conventional turbocharger which does no more than drive a compressor. In a conventional turbocharger, out of balance forces and shaft vibration forces are resisted by journal oil films distributed equally around the circumference of the inner and outer bearings as there are no off axis external forces on the system. In a power turbine in contrast, the gear drive supported on the end of the shaft remote from the turbine generates a reaction force which gives rise to an external directional force on the turbine shaft. This external force significantly increases the load, particularly on the bearing closest to the gear. This directional load causes the shaft to be displaced such that the oil film on the side of the bearing opposite the applied force can become very thin.

At high power transmission levels, the directional load can become so great that, in the limit, the floating bearing stops rotating within the housing. As a result, the load carrying capacity of the bearing drops and failure of the shaft bearing system can occur.

It is an object of the present invention to obviate or mitigate the problems outlined above.

According to the present invention, there is provided a turbocharger comprising a drive shaft supporting at one end a turbine arranged in use to be driven by exhaust gases from an internal combustion engine and supporting at the other end a drive connection which in use is coupled to an output shaft of the engine, wherein the shaft is supported in a housing by a first bearing adjacent to the turbine and a second bearing adjacent the drive connection, the first and second bearings each define an inner bearing surface relative to which the shaft rotates and an outer bearing surface which rotates relative to the housing, and the first and second bearings are mechanically coupled together such that they rotate relative to the housing at the same speed.

In embodiments of the present invention, the driving effect of the bearing adjacent the turbine end of the shaft is used to maintain the rotational speed of the more highly directionally loaded gear at the other end of the shaft. As a result, when high gear loads are applied to the shaft, the bearing at the end of the shaft remote from the turbine is prevented from slowing and losing load carrying capacity by driving torque which is delivered from the less directionally loaded bearing at the end of the shaft adjacent the turbine.

The driving effect at the gear end of the bearing is produced by modifying the relative surface areas and operating clearances of the inner and outer oil films, and by the areas of the bearing end faces abutting the shaft shoulders.

Preferably the first and second bearings are formed from a single tubular body through which the shaft extends. Such an approach is attractive from the point of view of ease of manufacture. It is possible however to provide a multi-part bearing assembly in which the first and second bearings are interconnected by a separate tube through which the shaft extends. The separate tube could be locked against rotation relative to the bearings by any appropriate means, for example interlocking castellations.

Radial apertures may be provided in the bearing assembly to provide oil drainage passageways. The first and second bearings may define axially-facing end surfaces which bear against retaining shoulders, the radial thicknesses of the end surfaces being equal or less than the radial spacing between the inner and outer bearing surfaces.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view through a turbocharger in accordance with the present invention;

Figure 2 is a perspective view of a one-part bearing incorporated in the turbocharger of Figure 1;

Figure 3 is an axial section through the bearing of Figure 2;

Figure 4 is a section on the line 4-4 of Figure 3;

Figure 5 is section on the line 5-5 of Figure 3; and

Figure 6 is a section showing one possible modification of the bearing of Figure 2.

Referring to Figure 1, the illustrated turbocharger comprises a shaft 1 which supports at one end a turbine 2 and supports at the other end a drive gear 3. The shaft 1 is supported in a one piece tubular bearing 4 which is supported within a housing 5. The housing 5 is secured to a body 6 which defines a volute 7 through which exhaust gases delivered from an internal combustion engine pass to apply torque to the turbine 2. A heat shield 8 protects the bearing assembly from the hot gases which drive the turbine 2.

One end of the bearing 4 abuts a shoulder 9 defined by the shaft whereas the other end of the bearing 4 abuts a flange 10 which forms part of a thrust bearing which maintains the axial position of both the bearing 4 and the shaft 1. The structure of the bearing 4 is shown in greater detail in Figures 2 to 5.

Referring to Figures 2 to 5, the bearing 4 defines a first bearing having an inner bearing surface 11 and an outer bearing surface 12 and a second bearing having an inner bearing surface 13 and an outer bearing surface 14. The surfaces 11, 12, 13 and 14 are defined at the ends of a tubular body having a central section 15 the inner and outer diameters of which are less than the diameters of the inner bearing surfaces 11, 13 and the outer bearing surfaces 12, 14 respectively. Oil passageways 16 extend between the inner and outer bearing surfaces and oil drainage apertures 17 may be provided in the central section 15 to ensure that oil can drain freely from the inner bearing surfaces. Axial ends 18 of the tubular bearing structure have the same outer diameters as the outer bearing surfaces 12, 14 and greater internal diameters than the inner bearing surfaces 11, 13.

Given that the bearing 4 is formed in one piece, the bearings defined at opposite ends thereof must rotate at the same speed. Thus the rotational speed of the bearing surfaces supporting the end of the shaft adjacent the gear 3 must be the same as the rotational speed of the bearing surfaces supporting the end of the shaft adjacent the turbine 2. Thus high loads at the end of the shaft adjacent the gear 3 are prevented from slowing down and thereby reducing the load carrying capacity of the adjacent bearing surfaces.

In the illustrated example the bearing 4 is made from a single component. The central section 15 of this single component has an internal diameter greater than that of the turbocharger shaft and an external diameter less than that of the adjacent housing so as to avoid hydrodynamic drag resisting rotation of the shaft. This may not, however, be necessary in all embodiments of the invention. Rather, the proportions of the central section 15 of the bearing may be varied in order to give the correct hydrodroynamic force balance on the bearing. For example, it may not be necessary to provide a recess along the inner diameter in order to maximise the bearing speed. Thus, in alternative embodiments of the invention the inner diameter of the central section 15 may be smaller or larger than that illustrated and for instance may be equal to the diameter of the surfaces 11 and 13. Similarly, the outer diameter of the central section 15 may be smaller or larger than illustrated and may for instance be equal to the diameter of the surfaces 12 and 14.

The radial thickness of the end portions of the bearing body 4 which define the surfaces 18 can also be adjusted as necessary to modify the area of the end faces 18 to ensure suitable rotational speeds for the bearing body 4. For instance, the axial ends 18 of the tubular bearing structure may have outer diameters which are smaller than the diameter of the outer bearing surfaces 12 and 14 and internal diameters which are equal to the inner bearing surfaces 11 and 13.

Rather than forming the bearing 4 as a one-piece tube, the bearing could be in the form of two separate bearings linked by a tube arranged to engage the bearings such that the two bearings are constrained to rotate at the same speed.

It would be possible to axially locate the bearing 4 using circlips or the like but the use of such devices can be avoided as shown in the illustrated embodiment by arranging for the bearing 4 to bear axially against the shoulder 9 on the turbine shaft and against the thrust bearing flange 10 at the gear end of the shaft.

A further possible modification of the bearing of Figure 2 is illustrated in Figure 6 which is a cross-section corresponding to the section taken on the line 4-4 of Figure 2 but of a modified bearing in which an annular groove 19 is provided in the outer surface of the bearing. The groove 19 links the openings of the oil passageways 16 and ensures that the oil supply holes in the housing 5 from which oil is supplied to the bearing are never blocked.

Claims

1. A power turbine comprising a drive shaft supporting at one end a turbine arranged in use to be driven by exhaust gases from an internal combustion engine and supporting at the other end a drive connection which in use is coupled to an output shaft of the i.c. engine, wherein the shaft is supported in a housing by a first bearing adjacent to the turbine and a second bearing adjacent the drive coupling, the first and second bearings each define an inner bearing surface relative to which the shaft rotates and an outer bearing surface which rotates relative to the housing, and the first and second bearings are mechanically coupled together such that they rotate relative to the housing at the same speed.

2. A turbocharger according to claim 1, wherein the first and second bearings are formed from a single tubular body through which the shaft extends.

3. A turbocharger according to claim 1, wherein the first and second bearings are separate components interconnected by a tubular body through which the shaft extends.

4. A turbocharger according to claim 2 or 3, wherein the tubular body defines radial apertures to provide oil drainage passage ways.

5. A turbocharger according to any preceding claim, wherein the first and second bearings define axially-facing end surfaces which bear against retaining shoulders, the radial thickness of the end surfaces being less than or equal to the radial spacing between the inner and outer bearing surfaces.

6. A turbocharger substantially as hereinbefore described with the reference to Figures 1 to 5 of the accompanying drawings.

Abstract

A turbocharger in which a drive shaft supports at one end a turbine driven by exhaust gases from an internal combustion engine. The end of the drive shaft remote from the turbine supports a drive connection which is coupled to an output shaft of the driving engine. The shaft is supported in a housing by a first bearing adjacent the turbine and a second bearing adjacent the drive coupling. The first and second bearings each define an inner bearing surface relative to which the shaft rotates and an outer bearing surface which rotates relative to the housing. The first and second bearings are mechanically coupled together such that they rotate relative to the housing at the same speed. Coupling the two bearings together ensures that directional forces applied to the bearing at the end adjacent the drive connection which might cause that bearing to seize are resisted by torque delivered from the bearing at the other end of the shaft.

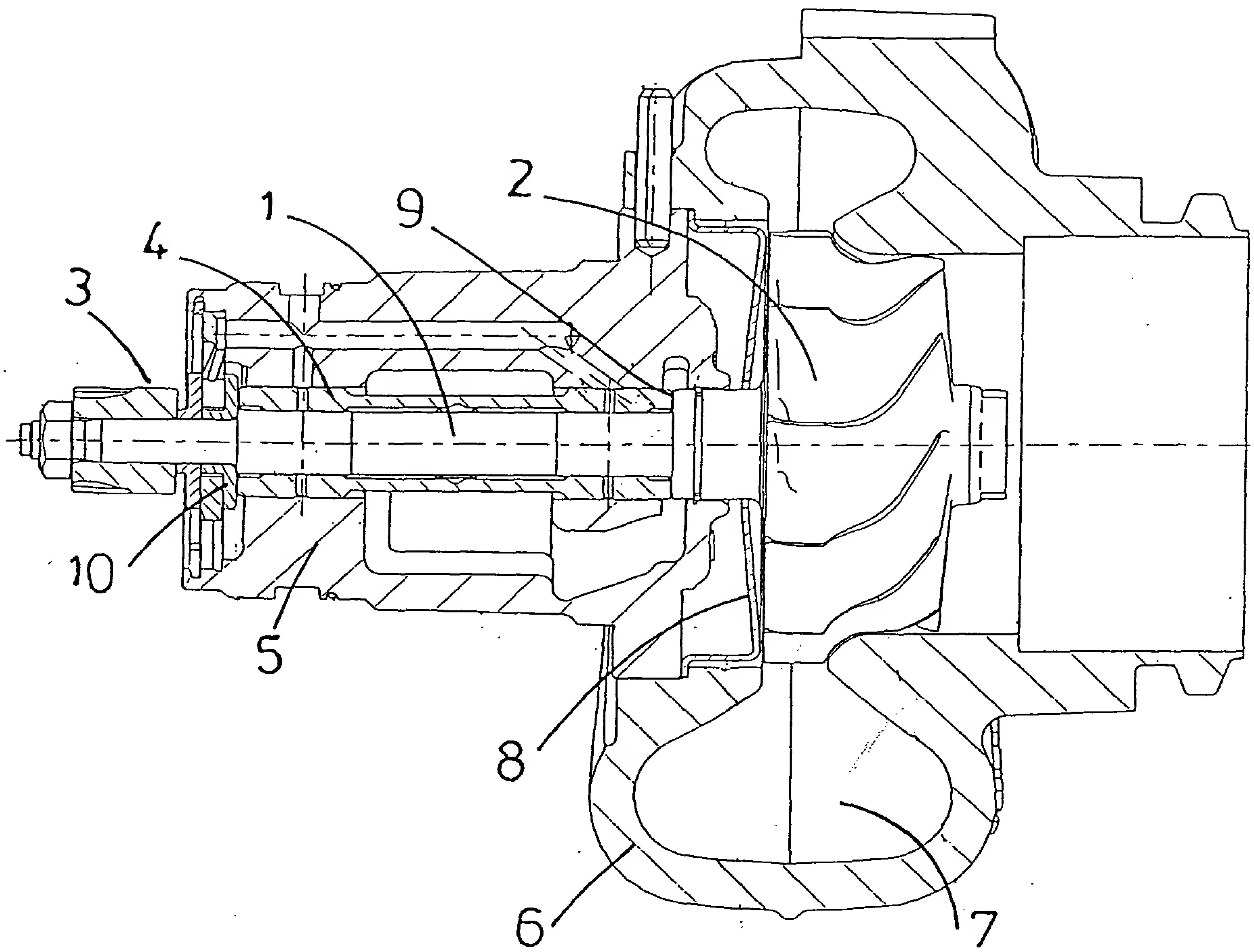

FIG. 1

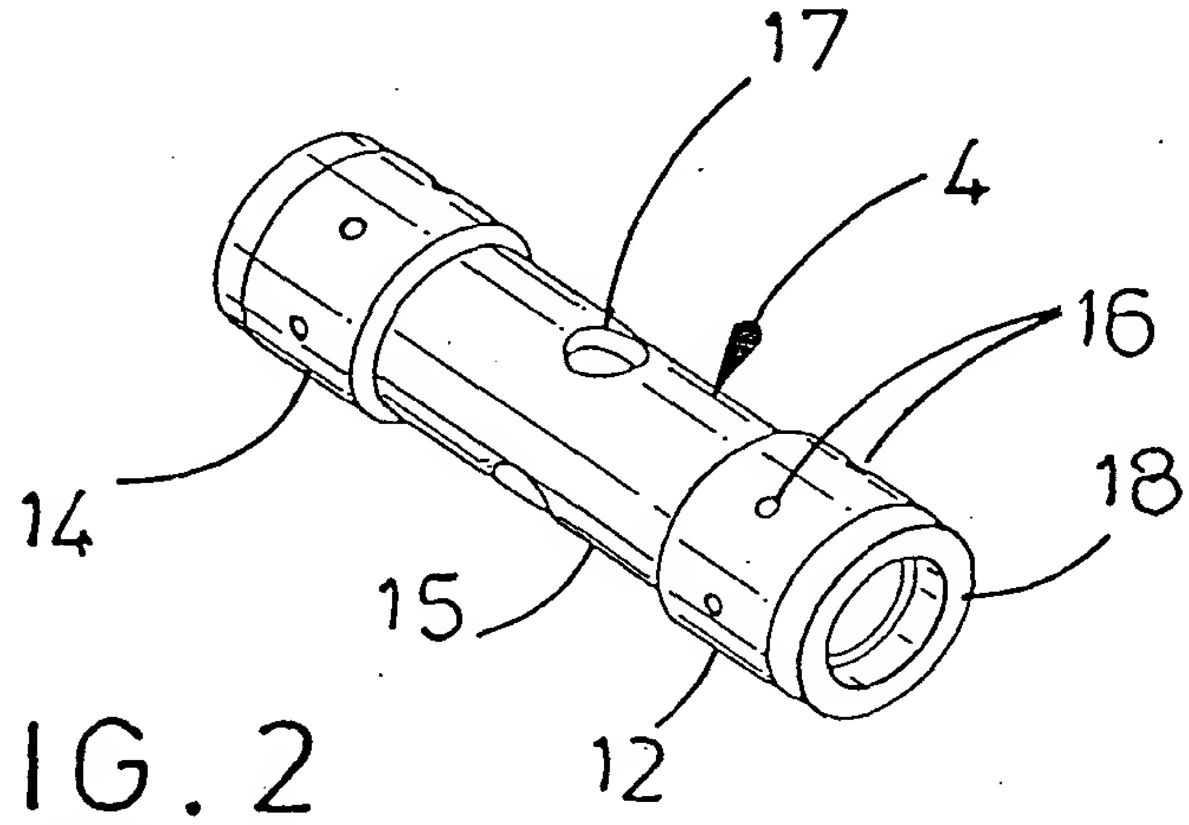

FIG. 2

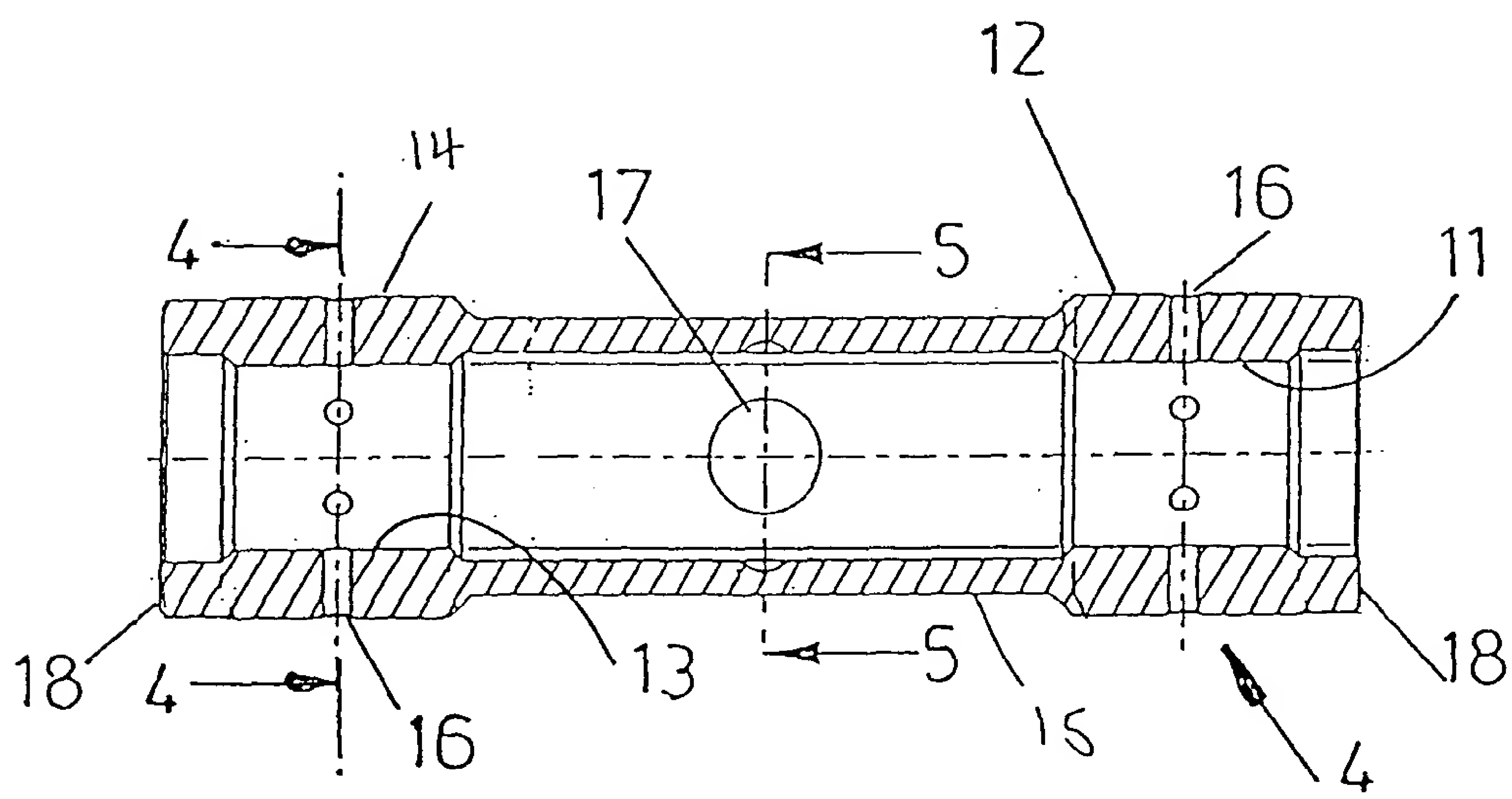

FIG. 3

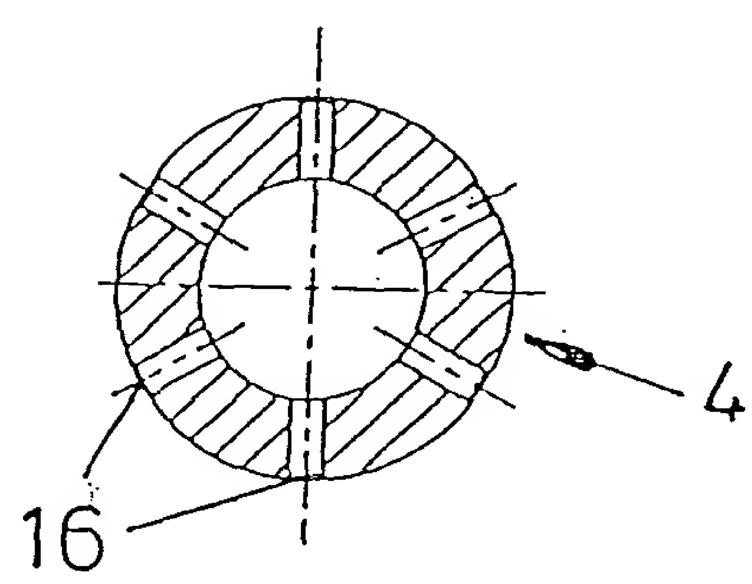

FIG. 4

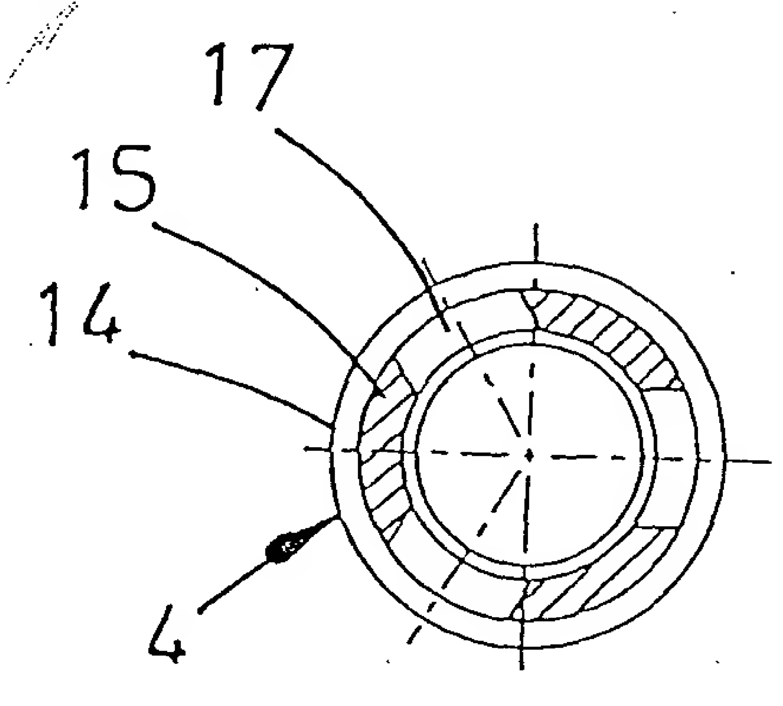

FIG. 5

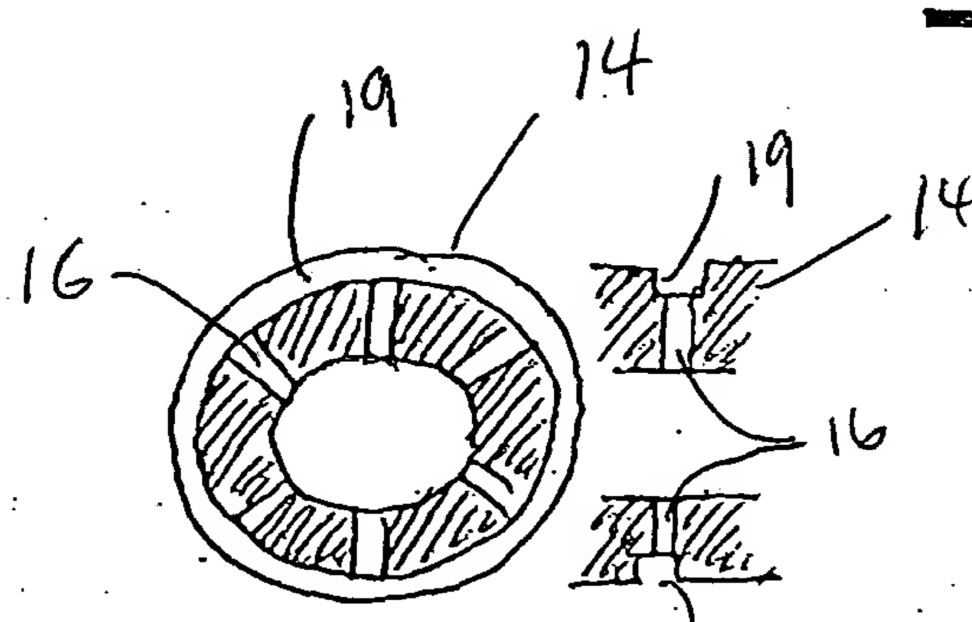

FIG 6